Proposal of Technologies for User-Oriented Road Design

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ABSTRACT

Due to the complexity of human behavior when driving, inadequate factors that influence the performance of driving-related tasks can lead to fatal accidents.

Therefore, road design should carefully consider the driver's characteristics for road safety. In addition, consideration is required to establish clear and concrete guidelines to be applied to road design, and improve safety in road driving.

This study will introduce several technologies intended to control human factors on roadways. For this purpose, the research focused on the following issues;

- Optimal amount of information on road sign
- Minimum distance between the tunnel and the interchange
- Proposal of methods of pavement marking for speed reduction

This proposal will contribute to establishing the standard criteria for human centered road design.

1. INTRODUCTION

1.1 BACKGROUND

Road design should carefully consider the following factors: function, safety, economy, environment, pleasantness, and construction & maintenance.

Particularly, the higher traffic accident rate in Korea in comparison with that of other countries reemphasizes the urgent necessity of the safe road design.

As a potential alternative, some countries have initiated research on human factors and ergonomics for user-oriented road design, especially focusing on driver performance and driver error, and applied research results to actual road design. But the road design technologies which consider the driver's characteristics in Korea have been inactive.

So road designs should be needed to improve its regulation criteria for road safety. For this, three items as parts of research projects supported by Korea Ministry of Construction & Transportation (MOCT) are introduced.

1.2 RESEARCH SCOPE

This study aims to research human factors to improve road facilities in Korea. For this purpose, this research introduces the following issues:

- Optimal amount of information on road sign
- Minimum distance between the tunnel and the interchange
- Proposal of methods of pavement marking for speed reduction

2. METHODOLOGY

2.1 EQUIPMENT SELECTION

Two pieces of equipment for these studies were used as follows;

- Driving Simulator: This equipment allowed the subjects to drive in a 3-D virtual reality.
- Eye Tracking (EMR-8B): This equipment can record the targets that subjects intend to observe. This device was used in the study of ‘Optimal number of information on road sign’

Driving Simulator (K-ROAD)

Eye Tracking (EMR-8B)

Figure 1. Experimental Equipment

3. RESEARCH ITEMS

3.1 RESEARCH APPROACH

❑ Optimal amount of information on road sign

Thirty people between the ages of twenty and seventy took part in this experiment. Information on road signs in this study ranged from 4 guide names to 10 ones. Total length of the route for the experiment was 31km (19.4miles). The procedure for this experiment was as seen in figure 4.

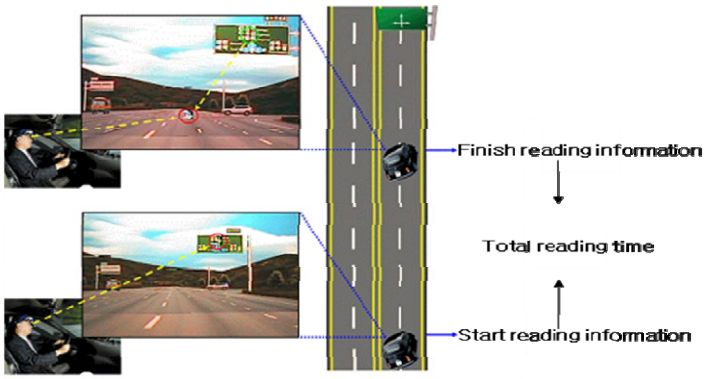

Figure 2. Experimental Procedure for Road Signs

The formula of the misreading rate was used for study. This is defined as the sums of all words that the driver fails to read correctly or read completely out of the total words on the road signs. Finally, optimal number of information on road sign was set through developed logistic model.

❑ Minimum distance between the tunnel and the interchange

Thirty eight people between the ages of twenty and seventy took part in this experiment by using the driving simulator. Several steps are identified between the tunnel and the interchange.

Light Adaptation Distance (L1); Distance where drivers must adapt form dark to light as they come out of the tunnel.

Information Intake Distance (L2); Distance where road users read information on road sign.

Lane Change Distance (L3); Distance where road users change lanes for the destination (interchange).

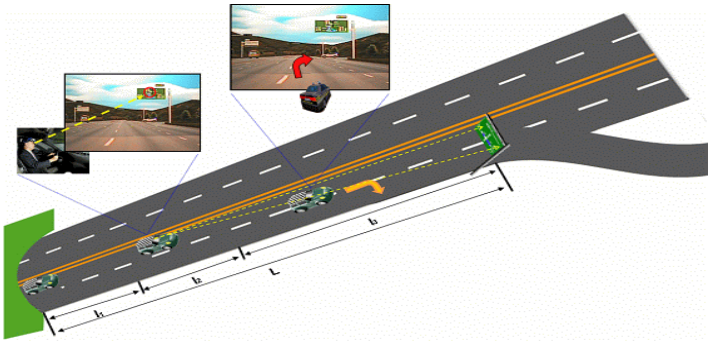

Figure 3. Experimental Procedure for the Tunnel and the Interchange

A calculation of minimum distance between the tunnel and the interchange was drawn from the sums of L1, L2, and L3.

❑ Proposal of methods of pavement marking for speed reduction

This study proposes various pavement markings for speed reduction on the national highway curves. For this, forty one people between the ages of twenty and seventy took part in this experiment by using the driving simulator and several perceptual countermeasures that have been used abroad were reviewed. A study analyzed which patterns are effective to reduce a speeding on the national highway curves. Pavement markings suggested through a literature review as seen in figure 6.

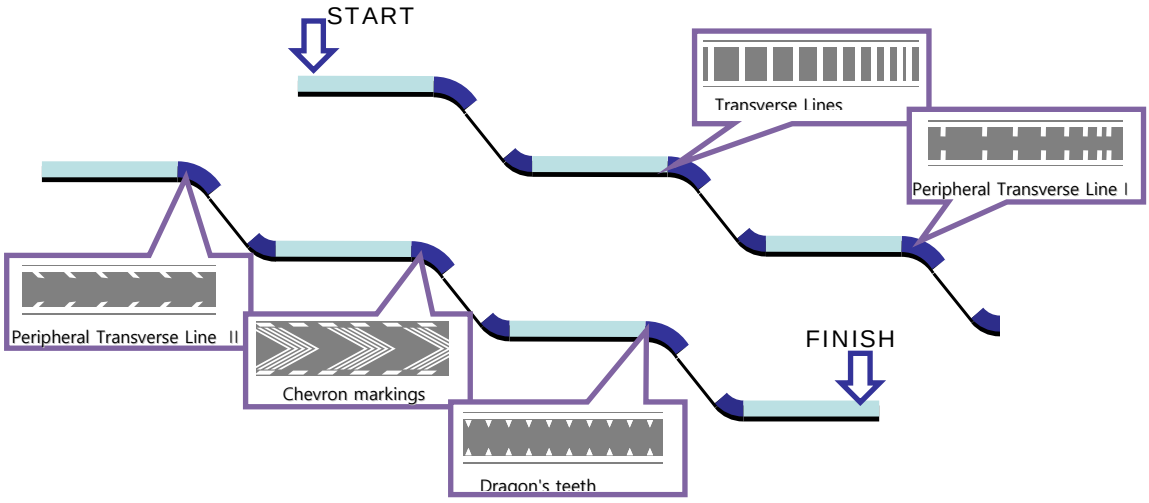

Figure 6: Selected Pavement Markings for road curves

4. SUMMARY OF RESULTS

❑ Optimal amount of information on road sign

In the experiment of simulation, the misreading rate was increased constantly in proportion of the number of road signs. Statistical verification in regression analysis showed a significance level. But Adjusted R Square was very low. Reading time in the age range with regression analysis found that the higher the proportion of age, the higher the rate of reading time by 0.106sec. Finally, a binary logistic model was used to find the main factors. As the results, 6 names per road sign was the ideal standard. When considering aging, 4 guide names per road sign proved best.

❑ Minimum distance between the tunnel and the interchange

In this research, the Minimum distance between the tunnel and the interchange (the onset of the deceleration's lane) was set up for potential guideline. For this experiment, statistical analysis for light adaptation, information intake and lane-changing time were carried out. As a result, the

minimum length between the tunnel and the interchange (the onset of deceleration's lane) indicated 500m long, but the maximum length showed 800m long in case of 80km/h on the national highways.

❑ Proposal of methods of pavement marking for speed reduction

As a result of this study, overall, these techniques had a subtle effect on vehicle speeds in the driving simulator.

Table 1. results of speed comparison by techniques

	Average Speed (km/h)	Speed Comparison by techniques					
		Transverse Lines	Peripheral Transverse Line Ⅰ	Peripheral Transverse Line Ⅱ	Chevron Markings	Dragon's Teeth	Unmarked Sections
①	Highest speed on straightaway	90.5	89.0	88.6	87.5	91.0	90.2
②	Onset pavement marking	77.8	76.5	74.3	76.0	77.1	79.6
③	Speed difference (①-②)	12.7	12.5	14.3	11.5	13.9	10.6

Peripheral Transverse Line Ⅱ showed the most effective speed reduction as seen in table 1. However, statistically the effectiveness of speed reduction on every section was not different at the 95 percent confidence level as seen in table 2. Only Peripheral Transverse Line Ⅱ had an effect on reducing speeds at the 90 percent confidence level when compared to unmarked section.

Table 2. Result of ANOVA(the effectiveness of speed reduction by techniques)

(I) VAR00001	(J) VAR00001	Mean Difference (I-J)	Sig.
Peripheral Transverse Line Ⅱ	Transverse Line	1.57857	.484
	Peripheral Transverse Line Ⅰ	1.72381	.445
	Chevron Marking	2.74286	.225
	Dragon's teeth	.42857	.849
	Unmarked sections	3.71667	.100

5. DISCUSSION

Based on the research, three items are introduced to improve road facilities. These results proved them to be an effective method to improving the road safety.

However, each item should be considered as follows.

- 'Optimal amount of information on road sign'; need to consider a suitable positioning and a font size on road signs.
- 'Minimum distance between the tunnel and the interchange'; need to consider various traffic environmental problems which had not been reflected on in this project then apply the standardization of the minimum distance between interchange and rest area.
- 'Proposal of methods of pavement marking for speed reduction'; need to these treatments are an effective long-term countermeasure for speeding and then application of the color contrasts (ex; a dark asphalt pavement with white marking) can be considered.

6. ACKNOWLEDGMENTS

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